

# **RoboCupRescue-Robot League Team**

## **Red Knight RoboRescue Squad, United States of America**

Yellow Robot: Timothy Tursich, Jim Galt  
Blue Robot: Sydney Crump, Gregory DeJute, John Fleischhacker, Michael Kosiek  
Green Robot: Bucky Phillips, Joe Martyn, Joe Schirmers  
Red Robot: James Muston, Teddy Pechacek, Sean McConville, Kellen Anderson  
Advisor: Timothy E. Jump

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### **Abstract**

- **High School Engineering Class**
  - One team/four robots
- **Each robot responsible for an individual task in the competition**
  - Yellow Robot: Mapping
  - Blue Robot: Thermal Imaging/Victim Identification
  - Green Robot: CO<sub>2</sub> Recognition/Victim Identification
  - Red Robot: Victim Tags/Sound Recognition/Visual Victim Identification
- **Teamwork Oriented**
  - Robots work together to complete tasks in least amount of time
  - If one robot malfunctions, mission can still be completed with other three
- **The following pages are divided into four sections, detailing each of the four individual robots.**



**Benilde-St. Margaret's School**  
**Red Knight RoboRescue Squad**  
**Yellow Robot**

## **1. Team Members and Their Contributions**

- Jim Galt                      Mechanical design, Mapping apparatus design
- Tim Tursich                Interface development, Mapping apparatus programming

## **2. Operator Station Set-up and Break-down**

- Set up laptops and establish wireless communication to robot

## **3. Communications**

- Wireless 802.11A
- "RemoteAccess" program
- Mini ITX board on robot

## **4. Control Method and Human-Robot Interface**

- Vehicle Maneuverability:
  - Remote Teleoperation using T6YG Controller
  - Operator drives the robot by manually calling the subroutines (forward, backward, left, right, etc.) through the Interactive C 4 interface
- Data Collection and Interpretation:
  - Partial Autonomy – Collision detection/avoidance under review
  - "Remote Access" program to communicate with the onboard computer
  - Robot uses mini ITX board for remote communication
  - Robot is controlled through subroutines written in Interactive C 4

## **5. Map Generation/printing**

- Laser distance sensor makes a full 360 degree sweep of the room, relays readings to the onboard computer
- Readings from the distance sensor and rotary encoder are analyzed and converted into (x, y) coordinates and then plotted in a graph in Excel
- Conversion equations:
$$A = (\text{Encoder's pulses per revolution}) / 360$$
$$R = \text{Count of rotary encoder clicks}$$
$$D = \text{Analog laser distance measurement}$$
$$x \text{ coordinate} = \cos ([ A * \text{Pi} ] / [ 180 * R ]) * D$$
$$y \text{ coordinate} = \sin ([ A * \text{Pi} ] / [ 180 * R ]) * D$$

## **6. Sensors for Navigation and Localization**

- Video camera(s)
- Infrared proximity sensors for collision detection/avoidance under review

## **7. Sensors for Victim Identification**

- Robot only maps the environment, so no sensors for victim identification are used

## **8. Robot Locomotion**

- Four electric Titan Monster 550 15,000 RPM motors
- Four wheel tank differential drive (Fig 1)
- Belt transmission (Fig 2)
- 33 to 1 gear ratio

## **9. Other Mechanisms**

- Mapping apparatus (Fig 3)
- Possible boom for mapping apparatus under review

## **10. Team Training for Operation (Human Factors)**

- Extensive knowledge of the subroutines used for locomotion
- Knowledge of how to operate Interactive C 4
- General computer operation skills
- Ability to interpret and navigate using streaming video from a video camera

## **11. Possibility for Practical Application to Real Disaster Site**

- Mapping system should work well enough for application to a real disaster site
- Small size (Fig 4)
- Easily portable
- Self-contained power source
- Wireless communication
- Areas in need of improvement
  - Little/no shielding for the wiring harness and internal components of the robot
  - Robot is too fast, movements can be jerky and inaccurate
  - Wheels used are not extremely versatile, do not grip well on dusty or debris-covered surface
  - No heat shielding for protection against fire and other sources of extreme heat

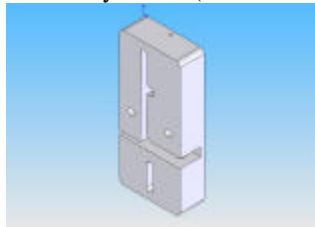
## **12. System Cost**

- Total system cost (with direct access to machine shop and 3D printer): \$3,500
- Total system cost (without direct access to machine shop and 3D printer): approximately \$5,400
- Parts:
  - 2x Innovation First Victor 884 speed controller (\$229.90)
    - Innovation First (<http://www.ifrobotics.com/>)
  - 4x Power Maxx Peak 2400 mAh battery (\$70.00)
  - 2x Traxxas 3906 E-Maxx motors, gearboxes (\$323.50)
    - Traxxas (<http://www.traxxas.com>)
  - 1x Buss ATC fuse block (\$25.00)
    - Bussman (<http://www.bussman.com>)

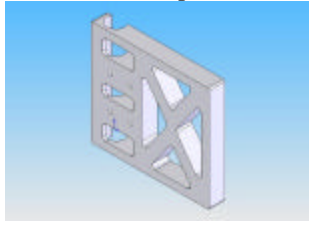
- 9x Double flange, 10 groove, nylon pulleys (\$53.82)
    - Smallparts (<http://www.smallparts.com>)
  - 5x Double flange, 40 groove, nylon pulleys (\$46.55)
    - Smallparts
  - 2x Bando synchro-link 260XL timing belt (\$9.30)
    - Smallparts
  - 1x Bando synchro-link 140XL timing belt (\$3.55)
    - Smallparts
  - 8x Wheel hubs (\$40.00)
    - Smallparts
  - 4x 6" Skyway caster wheels (\$18.00)
    - Skyway (<http://www.skywaywheels.com>)
  - 1x Futaba 53004 servo, R127DF receiver, T6YG controller (\$200.00)
    - Futaba (<http://www.futabarc.com>)
  - 1x BEI E20 rotary optical encoder (\$200.00)
    - BEI Technologies, Inc. (<http://www.beiduncan.com>)
  - 1x Banner LT3NU laser distance sensor
    - Banner Engineering (<http://www.bannerengineering.com>)
  - 1x Handyboard w/ Expansion board (\$350.00)
    - Gleason Research ([www.handyboard.com](http://www.handyboard.com))
  - Tyco Electronics switch W31-X2M1G-50 (\$15.00)
    - Tyco Electronics (<http://www.tycoelectronics.com>)
  - Aluminum Parts (\$10.00)
  - Wiring materials (\$50.00)
  - 1x Onboard computer (TBD)
  - 1x Control Laptop (TBD)
- Fabricated Parts (\$1,500 total without 3D Printer/ \$250 with 3D Printer)
    - Battery Mount



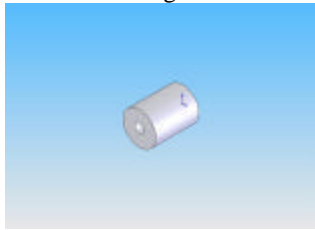
- Pulley Block (left – the right pulley block is a mirror of the left)



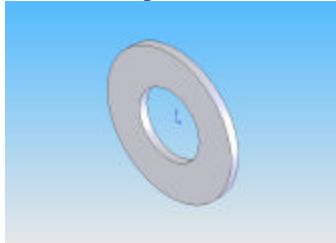
- Fuse Plate Spacer



- Wheel Plug



- Wheel Spacer



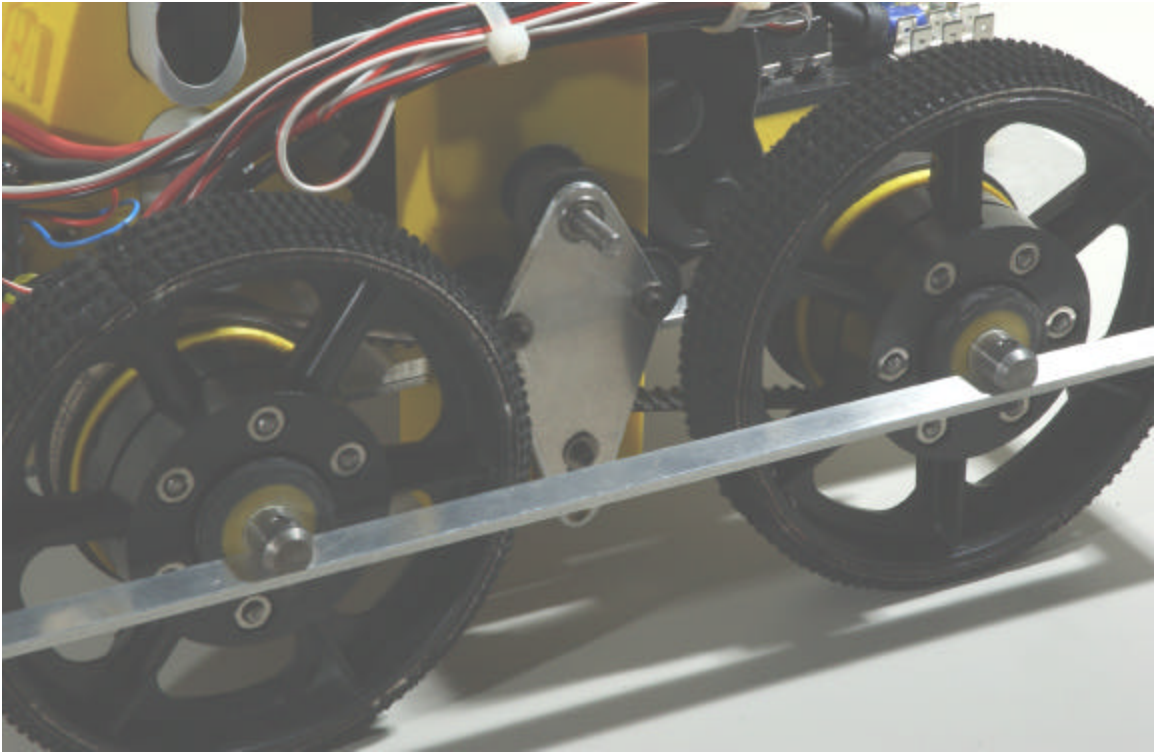


Fig 1

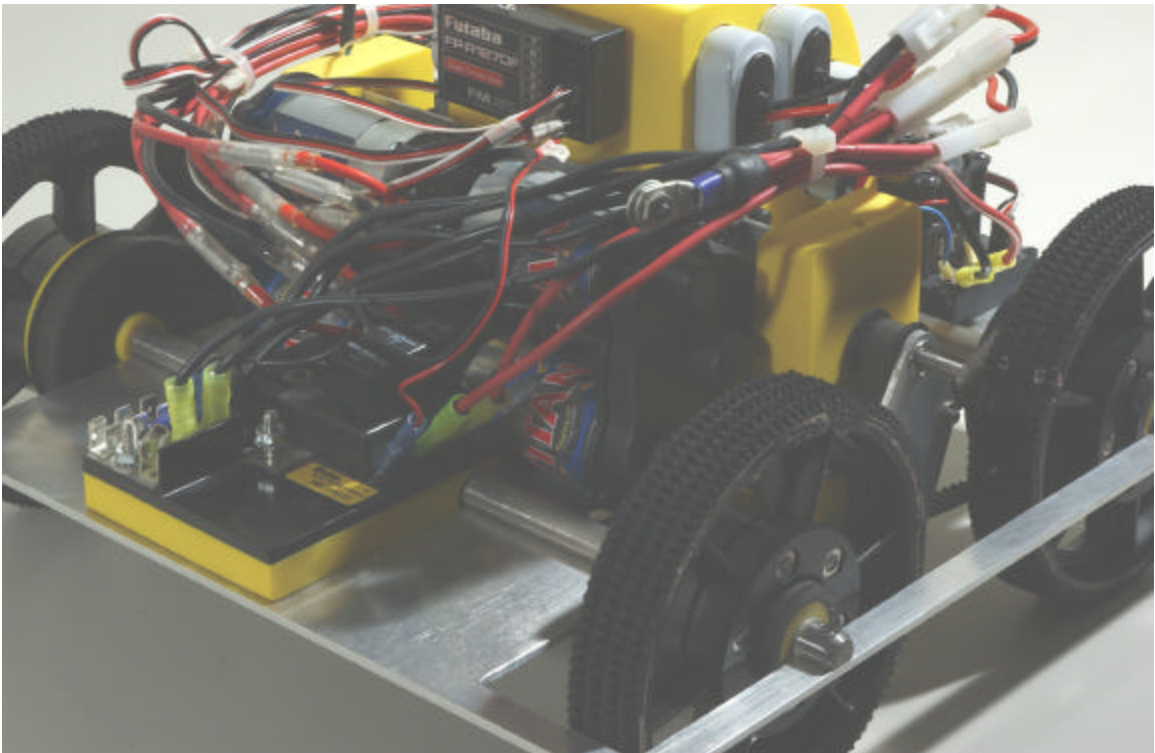


Fig 2

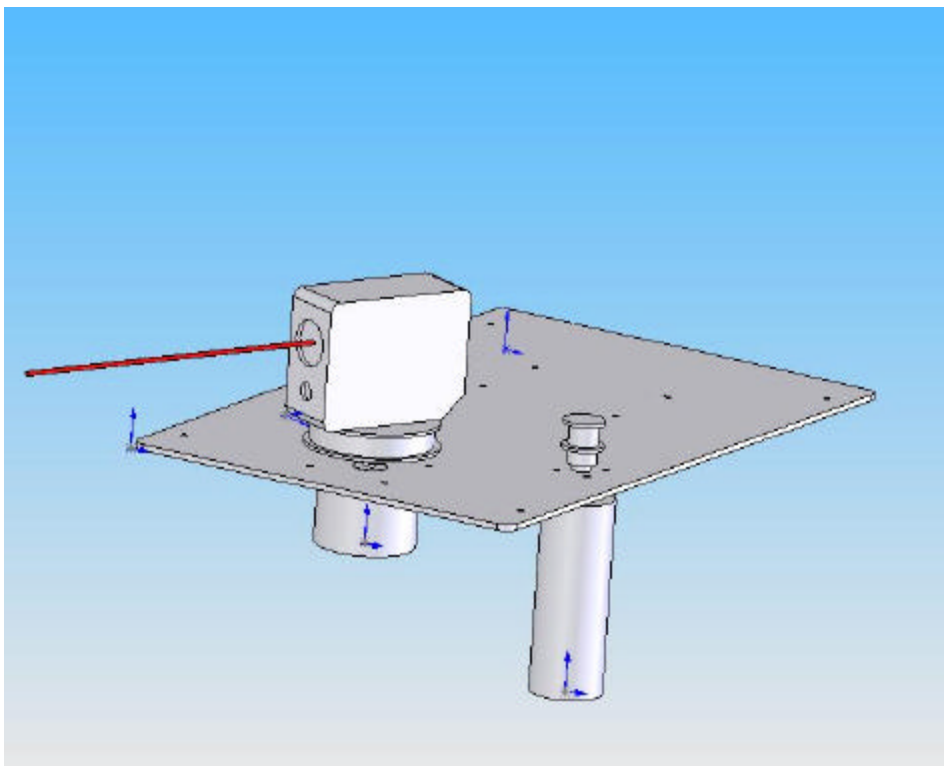


Fig 3



Fig 4

**Benilde-St. Margaret's School**  
**Red Knight RoboRescue Squad**  
**Blue Robot**

## **1. Team Members and Their Contributions**

- Michael Kosiek                      Mechanical Design
- Sydney Crump                      Mechanical Design
- John Fleischhacker              Operator, Electrical Design, Mechanical Design
- Gregory DeJute                    Electrical Design, Mechanical Design

## **2. Operator Station Set-up and Break-Down**

- Portable laptop station with wireless connection to robot

## **3. Communications**

- 802.11A wireless network
- Remote Access computer program
- Mini ITX board on Robot

## **4. Control Method and Human-Robot Interface**

- Vehicle Maneuverability
  - Remote control of robot using Futaba Skysport6 75MHz Controller
  - Operator drives robot using Remote Access through laptop keyboard to control robot
- Data Collection and Interpretation
  - Partial Autonomy -Collision detection/avoidance being considered
  - Remote Access program to communicate with the onboard computer
  - Robot uses mini ITX board for remote communication

## **5. Mapping**

- See Yellow Robot

## **6. VI. Sensors for Navigating**

- Cameras
  - One fixed mini wireless cameras with microphone
- Other Driving Sensors
  - Considering use of proximity sensor (Banner Sensor)

## **7. Sensors for Victim Identification**

- Thermal Imager
  - Irisys 1011 Universal Thermal Imager
    - Picks up infrared wavelengths that objects emit.

## **8. Robot Locomotion**

- Wheeled (Fig 8.1.1) and (Fig 8.1.2)
  - Two 6" wheels with rubber tread covering
  - Two front skids
- Motors (Fig 8.2.1)
  - Titan 550 15,000 RPM
  - Opposed Positioning (differential drive)
  - Direct drive to wheels
- Gear Box (Fig 8.3.1) and (Fig 8.3.2)
  - 11:3 gear reduction into transmission
    - 3:1 gear reduction using custom fabricated combination gear
  - Two Speed transmission
    - Futaba servo motors control transmission speed

## **9. Other Mechanisms**

- Additional Booms
  - Designing an arm for the thermal imaging camera so it can be raised to look over debris that might be in the way.

## **10. Team Training for Operation (Human Factors)**

- Learning Remote Access Program
- Practice driving the robot using the keyboard
- Practice analyzing Thermal Image to detect body heat

## **11. Possibility for Practical Application to Real Disaster Site**

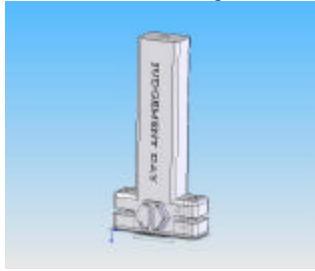
- Small Robotic design
  - Portability
    - Quick, direct access to disaster site
  - Easily navigates disaster sites
- Operation
  - Easily controlled from a wide range of distance from the disaster site using the Remote Access Program
  - Does not operate in 2.4 GHz
- Independent
  - Runs using its own power source
  - Not tethered

## 12. System Cost

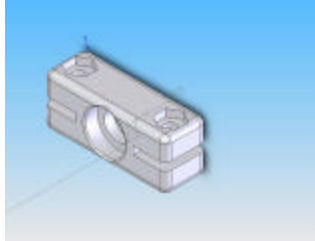
- Total system cost (with direct access to machine shop and 3D printer): \$2585.60
- Total system cost (without direct access to machine shop and 3D Printer): \$5117.60
- Parts
  - 2x Titan Motor: \$24/each
    - Traxxas (Traxxas.com)
  - 2x Piranha Battery: \$16/each
    - Hub Hobby
  - 2x Pivoted Axels : \$8
    - Traxxas (Traxxas.com)
  - 2x Transmission Gear Box (Gears, Casing, Bearings): \$49.75/each
    - Traxxas (Traxxas.com)
  - Aluminum Chassis: \$10 (Fig 12.1)
  - 2x Wheels : \$4.50/each
    - Skyway
  - 2x 8 Tooth 32 pitch gear: \$3.54/each
    - Small Parts Incorporated
  - 2x 24 Tooth 32 pitch gear: \$7.01/each
    - Small Parts Incorporated
  - Irisys 1011 Thermal Imager: \$1,800
    - (<http://www.irisys.co.uk/>)
    - Purchased from: Instrumentation.com (distributor)
  - 2x Futaba Speed Controller: \$114
    - Futaba-rc.com/
  - Fuse Panel \$30
    - Bussman.com
  - Electrical Wiring/Fuse: \$12
  - Stationary Camera: \$38
    - Purchased from Computer Geeks
  - Onboard Computer (Intended Part No Price)
- Fabricated Parts (\$250 with 3D Printer / \$2,232 total without 3D Printer)
  - Battery Box/ Fuse Holder



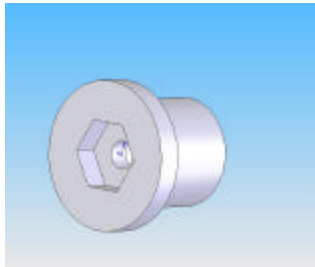
- Outside Bearing Blocks (2)



- Inside Bearing Blocks (2)



- Wheel Hub (2)



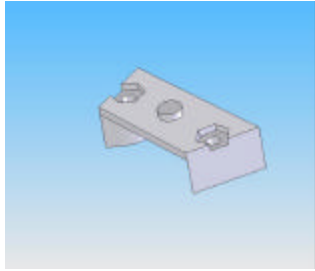
- Gear Plate (2)



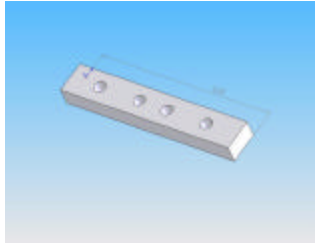
- Gear Plate Covering (2)



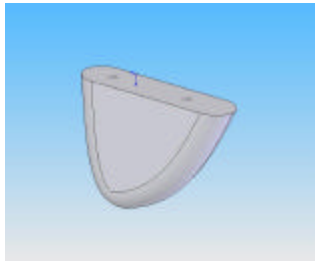
- Combination Gear Axel Cover (2)



- Motor Spacers (4)



- Skid (2)



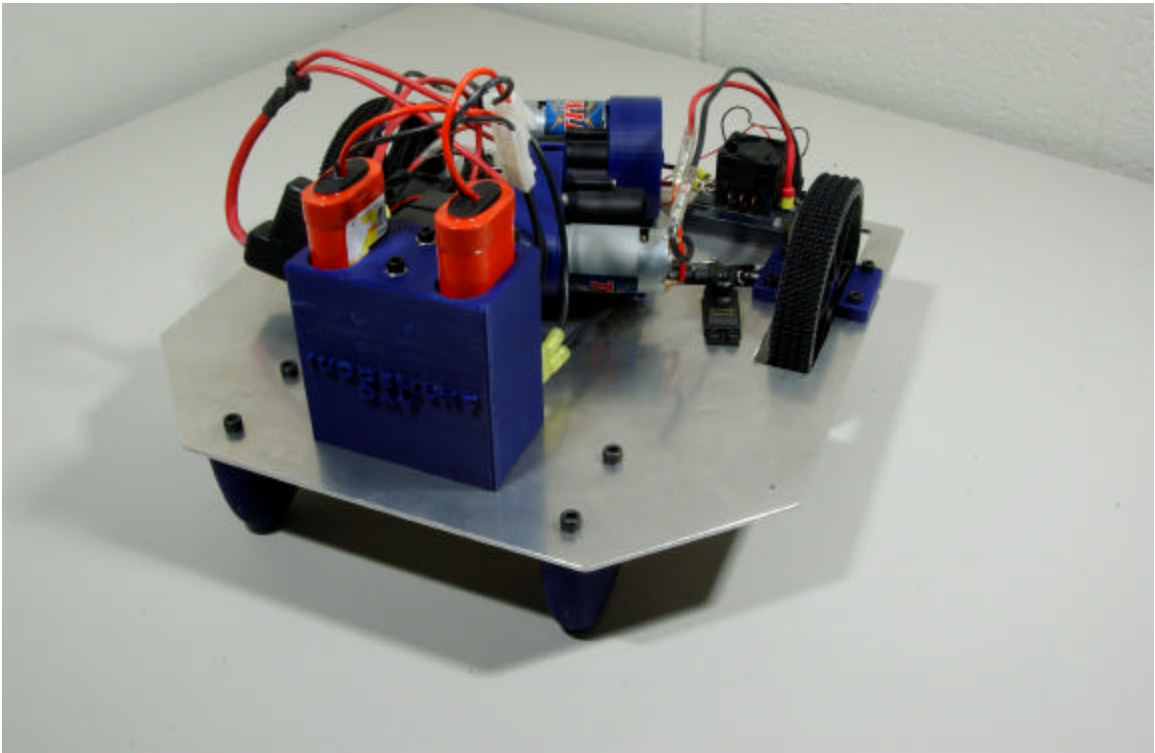


Fig 8.1.1

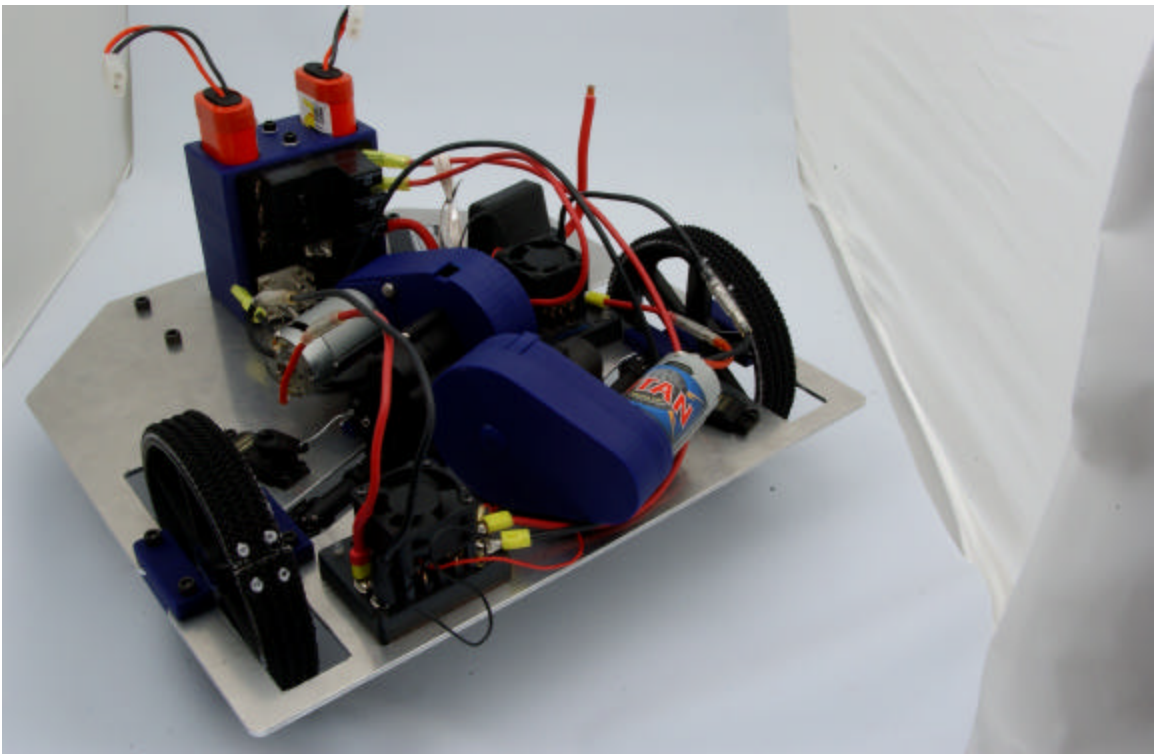


Fig 8.1.2

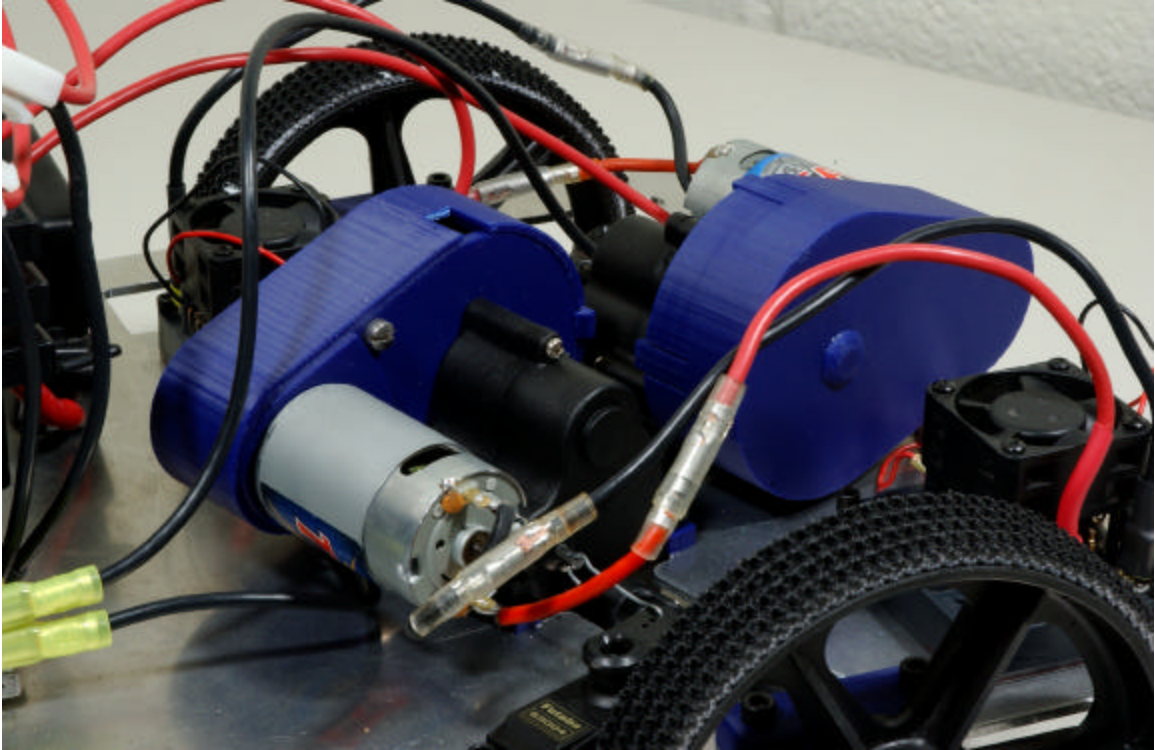


Fig. 8.2.1

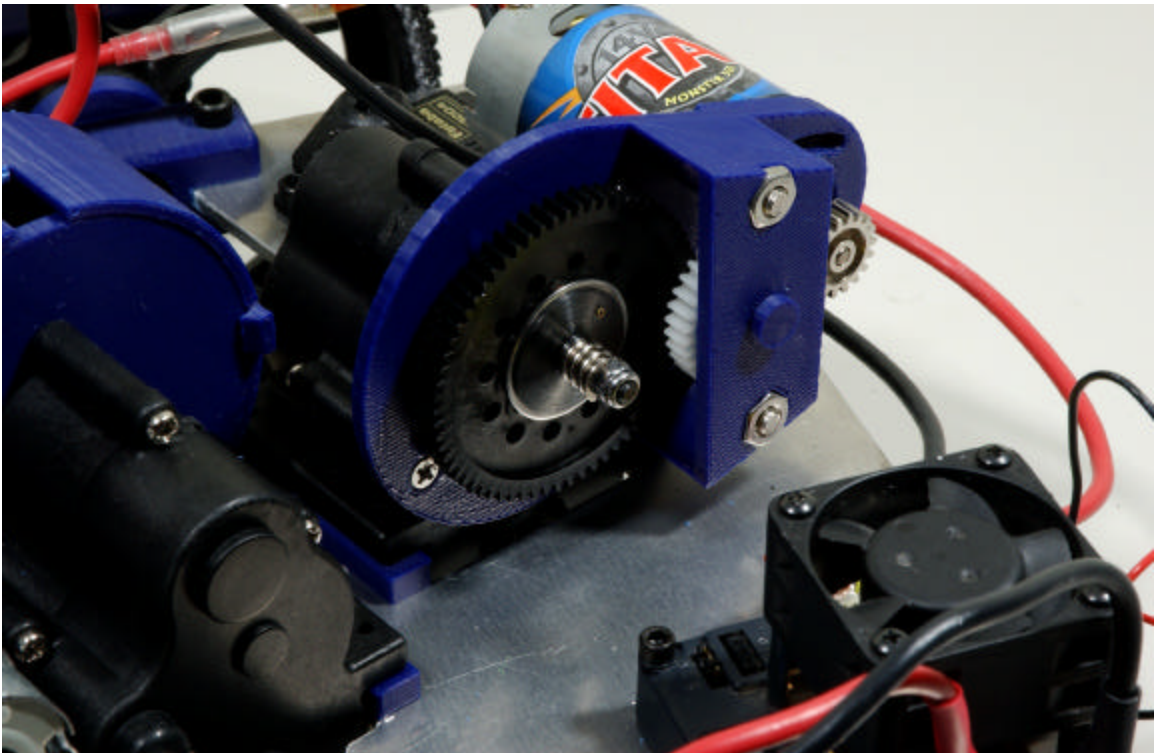


Fig 8.3.1

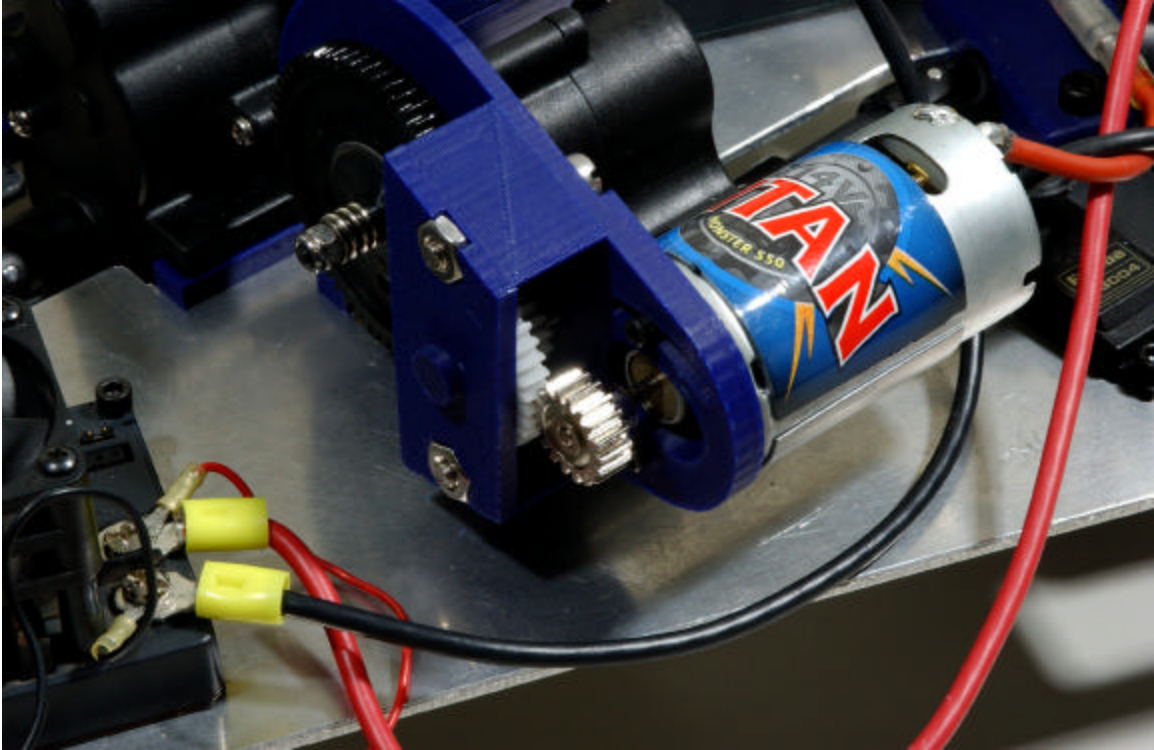


Fig 8.3.2

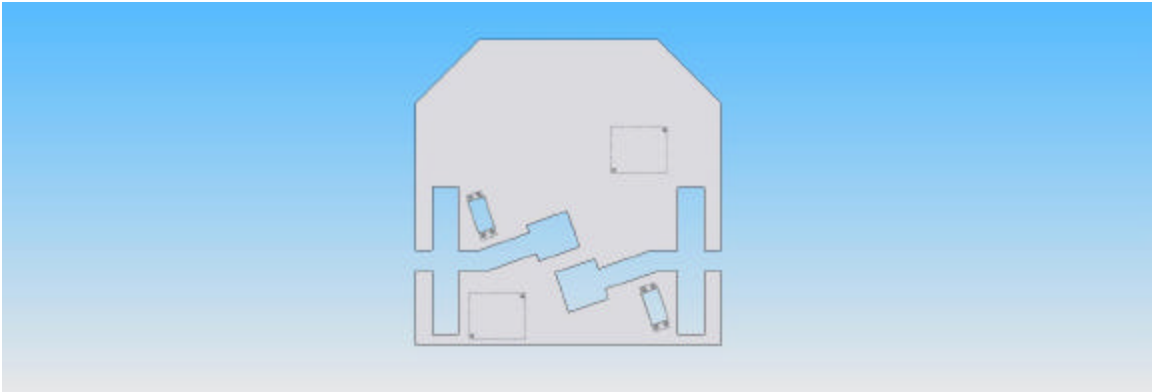


Fig 12.1

**Benilde-St. Margaret's School**  
**Red Knight RoboRescue Squad**  
**Green Robot**

**1. Team Members and Their Contributions**

- Joseph P. Martyn                      Controller Development
- Bucky T. Phillips                      Mechanical Design
- Joe D. Schirmers                      Operator

**2. Operator Station Set-up and Break-Down (10 minutes)**

- Notebook Computers wired to wireless hub
- Wireless hubs- link to robots

**3. Communications**

- 802.11A Wireless Standard
- Utilize remote access program

**4. Control Method and Human-Robot Interface**

- Vehicle Maneuverability
  - Remote Control of robot using Futaba Skysport T6YG 75MHz Controller
  - Remote Access using laptop keyboard to control robot with basic directional control
  - Proximity sensors for collision detection and avoidance
- Data Collection and Interpretation
  - Mini-ITX motherboard mounted to robot communicating to hub through 802.11A Wireless Card
  - Wireless control using Remote Access program

**5. Map generation/ printing**

- See Yellow Robot

**6. Sensors for Navigation and Localization**

- Systems to monitor navigation
- Video camera
- Proximity Sensors

**7. Sensors for Victim Identification**

- CO2 Sensors will be used to locate CO2 emissions and identify victims

## 8. Robot Locomotion

- 2 electric motors which run through a gearbox with a 11:3 ratio
- Axle attached to a pulley with a belt
- Belt attaches to a larger pulley which is directly attached to the wheels with 1:4 ratio

## 9. Other Mechanisms

- CO2 sensor omni-directional boom

## 10. Team Training for Operation (Human Factors)

- TBD

## 11. Possibility for Practical Application to Real Disaster Site

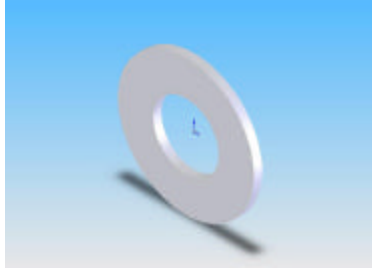
- Small and easily transportable
- Low cost
- Rechargeable and portable power source

## 12. System Cost

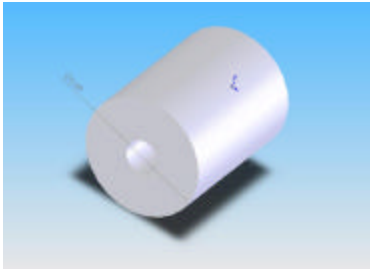
- Total System Cost (with direct access to machine shop and 3D Printer): \$3,239.38
- Total System Cost (without direct access to machine shop and 3D Printer): approximately \$5,369.38
- Parts:
  - 2x Futaba Speed Controller (\$228.00)
    - [www.futaba.com](http://www.futaba.com)
  - 2x Wheel (\$16.00)
  - 1x Fuse Panel (\$30.00)
    - [www.bussman.com](http://www.bussman.com)
  - 1x Power Switch (\$10.00)
    - [www.digi-key.com](http://www.digi-key.com)
  - Electronics/Miscellaneous Wiring (\$35.00)
  - 2x Double Flange, 10 groove, nylon pulleys (\$11.96)
    - [www.smallparts.com](http://www.smallparts.com)
  - 2x Double Flange, 40 groove, nylon pulleys (\$18.62)
    - [www.smallparts.com](http://www.smallparts.com)
  - 2x One-sided Nylon Timing Belt Size 18 (\$9.80)
    - [www.smallparts.com](http://www.smallparts.com)
  - 2x Titan (\$48.00)
    - [www.traxxas.com](http://www.traxxas.com)
  - 2x Piranha Battery 7.2 volts (\$32.00)
  - 1x Onboard Computer (\$700.00)
  - 1x Control Laptop (\$1500.00)

- Fabricated Parts / (\$250 with 3D Printer/\$1500 total without 3D Printer)

- Wheel Spacer



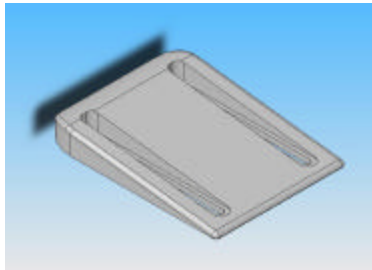
- Wheel Plug



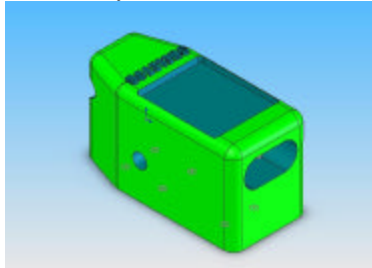
- Bearing Block



- Front Skid



- Battery Case/Axle Holder



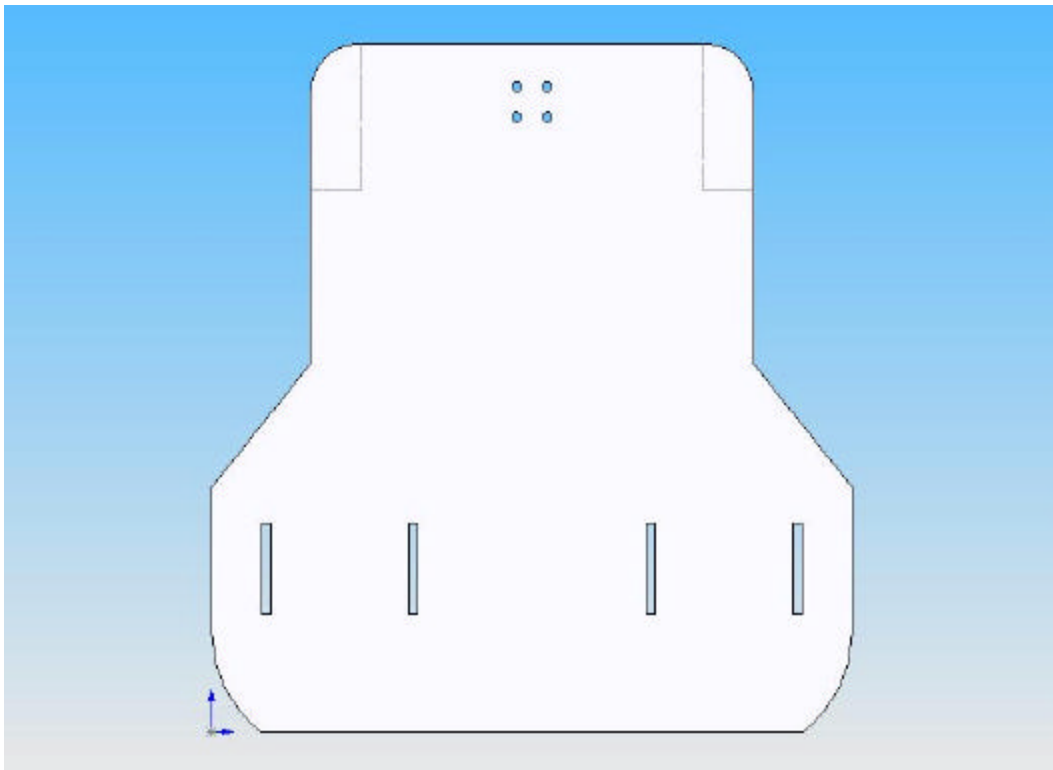


Fig 1

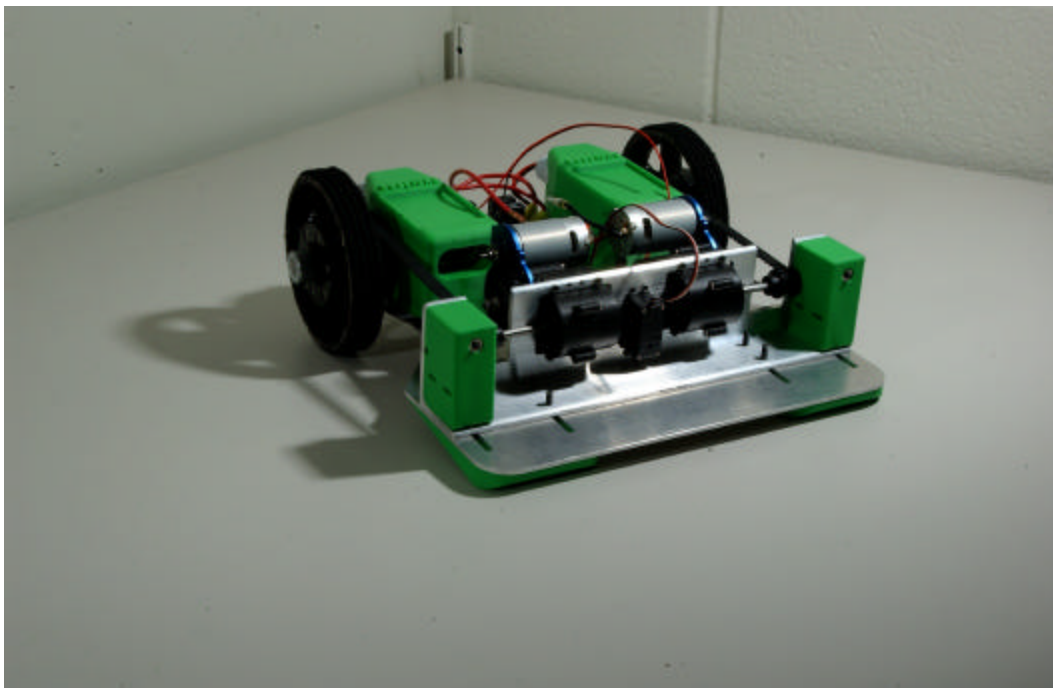


Fig 2

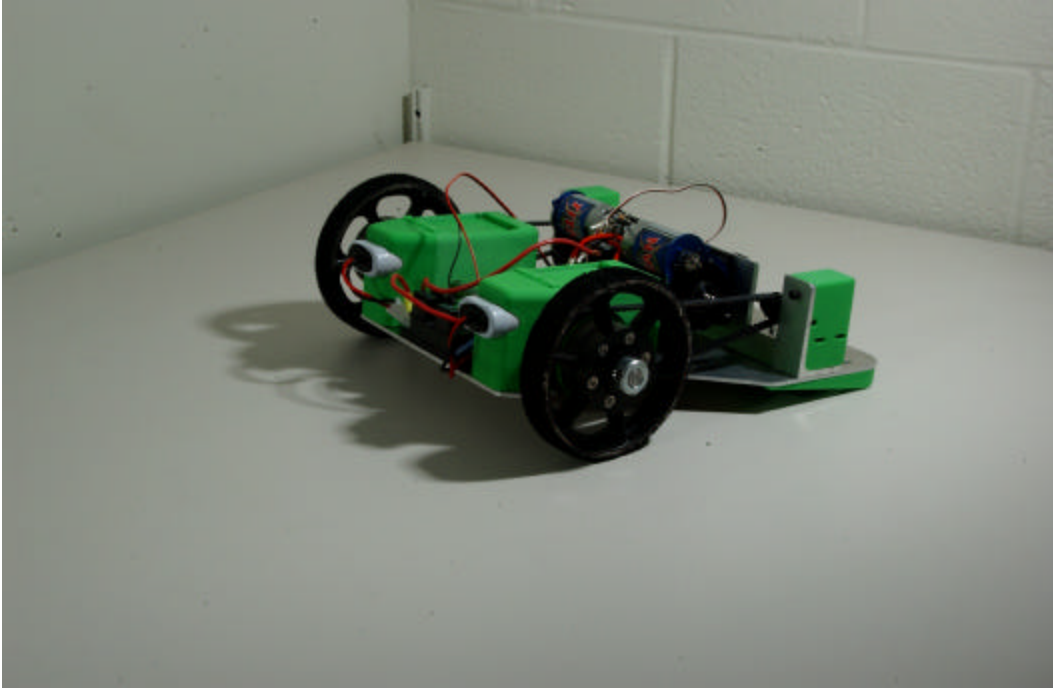


Fig 3

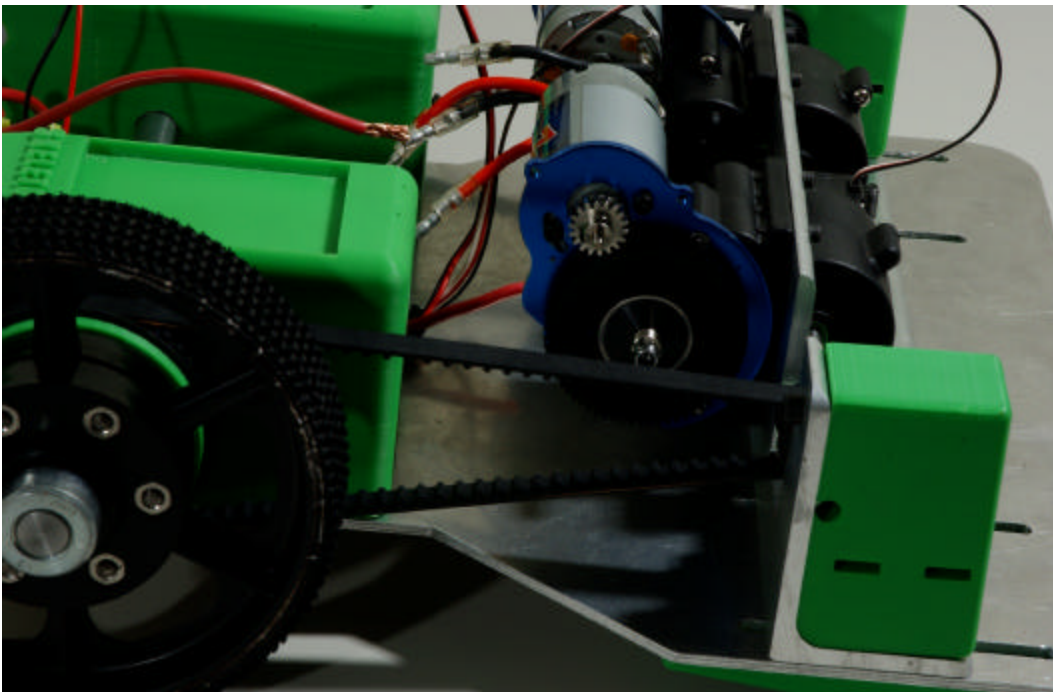


Fig 4

**Benilde St. Margaret's School  
Red Knight RoboRescue Squad  
Red Robot**

**1. Team Member/Contribution**

- Teddy Pechacek: CAD design
- Kellen Anderson: Maintenance/Operator
- James Muston: Team Manager
- Sean McConville: CAD design

**2. Operating Station and Breakdown**

- Set up laptops and establish wireless communication to robot

**3. Communication**

- Wireless 802.11A
- "Remote Access" program

**4. Control Method and Human Robot Interface**

- Vehicle Manoeuvrability:
  - Remote Teleoperation using T6YG Controller
  - Operator drives the robot by manually calling the subroutines (forward, backward, left, right, etc.) through the Interactive C 4 interface
- Data Collection and Interpretation:
  - Partial Autonomy – Collision detection/avoidance under review
  - "Remote Access" program to communicate with onboard computer
  - Robot uses mini ITX board for remote communication
  - Robot is controlled through subroutines written in Interactive C 4

**5. Map Generation/ Printing**

- See Yellow Robot

**6. Sensors for Navigation and Location**

- Proximity sensors for wall avoidance
- Camera for visual drive

**7. Sensors for Victim Identification**

- Camera (high power zoom)
- Microphone (low decibel)

## 8. Robot Locomotion

- Dual wheel differential drive
- 1:4 pulley system
- Opposing skid stabilization

## 9. Other Mechanisms

- Power rotating platform for 44x zoom camera

## 10. Team Training for Operation

- TBD

## 11. Possibility for practical application to real disasters

- Small/ affordable
- Easily portable
- Portable power source

## 12. System Costs

- Total system cost (with direct access to machine shop and 3D Printer): \$850
- Total system cost (without direct access to machine shop and 3D Printer): approximately \$3,460
- Parts:
  - 1x Batteries Plus Battery - \$20.00
  - 2x Bosch Drill motors/planetary gears - \$40.00
  - 1x Buss ATC Fuse Panel - \$30.00
    - Bussman (<http://www.bussman.com>)
  - 1x Digi-key Power Switch - \$10.00
  - 1x Futaba FP-R12 7DF Remote controller/servos - \$200.00
    - Futaba (<http://www.futabarc.com>)
  - 2x Innovation First Victor 883 Speed controllers - \$229.90
    - Innovation First (<http://www.ifrobotics.com/>)
  - 2x 6" Skyway caster wheels - \$9.00
    - Skyway (<http://www.skywaywheels.com>)
  - 2x Double flange, 40 groove, nylon pulleys - \$18.62
    - Smallparts (<http://www.smallparts.com>)
  - 2x Double flange, 10 groove, nylon pulleys - \$11.96
    - Smallparts
  - 2x Bando synchro-link 140XL timing belt - \$3.55
    - Smallparts
  - 4x Wheel Hubs - \$20.00
    - Smallparts
  - Wiring materials - \$35.00
  - Parts Misc.- \$30.00
  - Aluminum Parts - \$21.85
  - 1x Onboard computer - \$700.00
  - 1x Control Laptop - \$1500.00

- Fabricated Parts / (\$250.00 with 3D Printer/\$2793.00 total without 3D Printer)

- Axle spaces



- Battery case



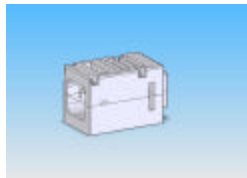
- Bearing Blocks



- Gear wedges



- Motor cases



- Skids



- Wheel Plugs



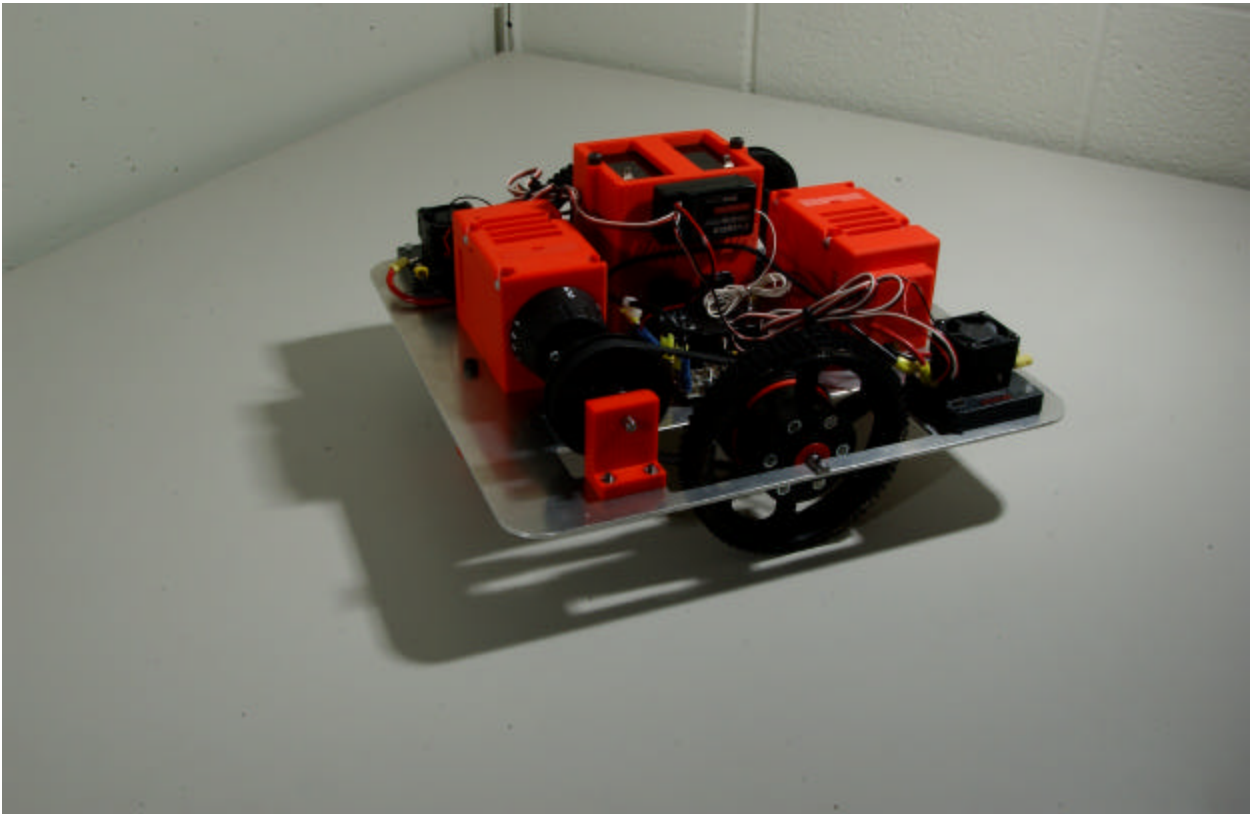


Figure 1

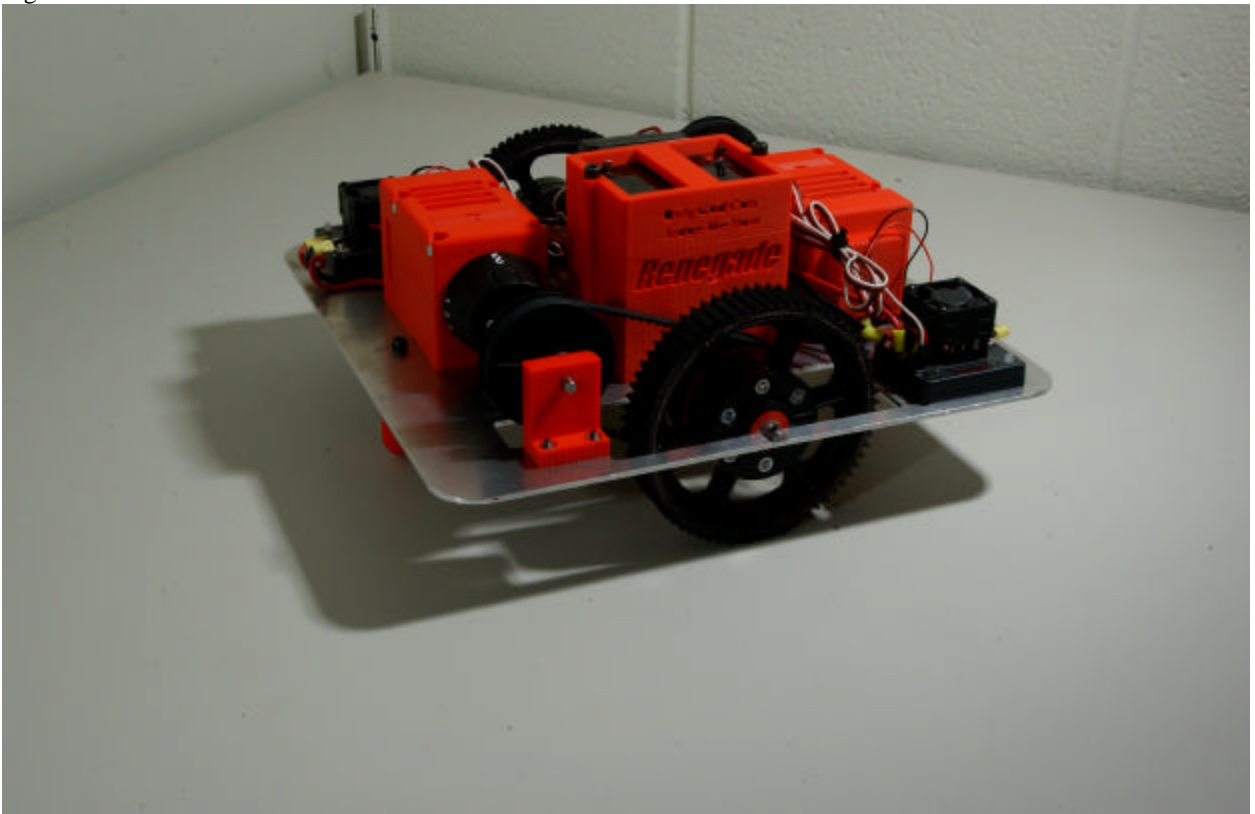


Figure 2

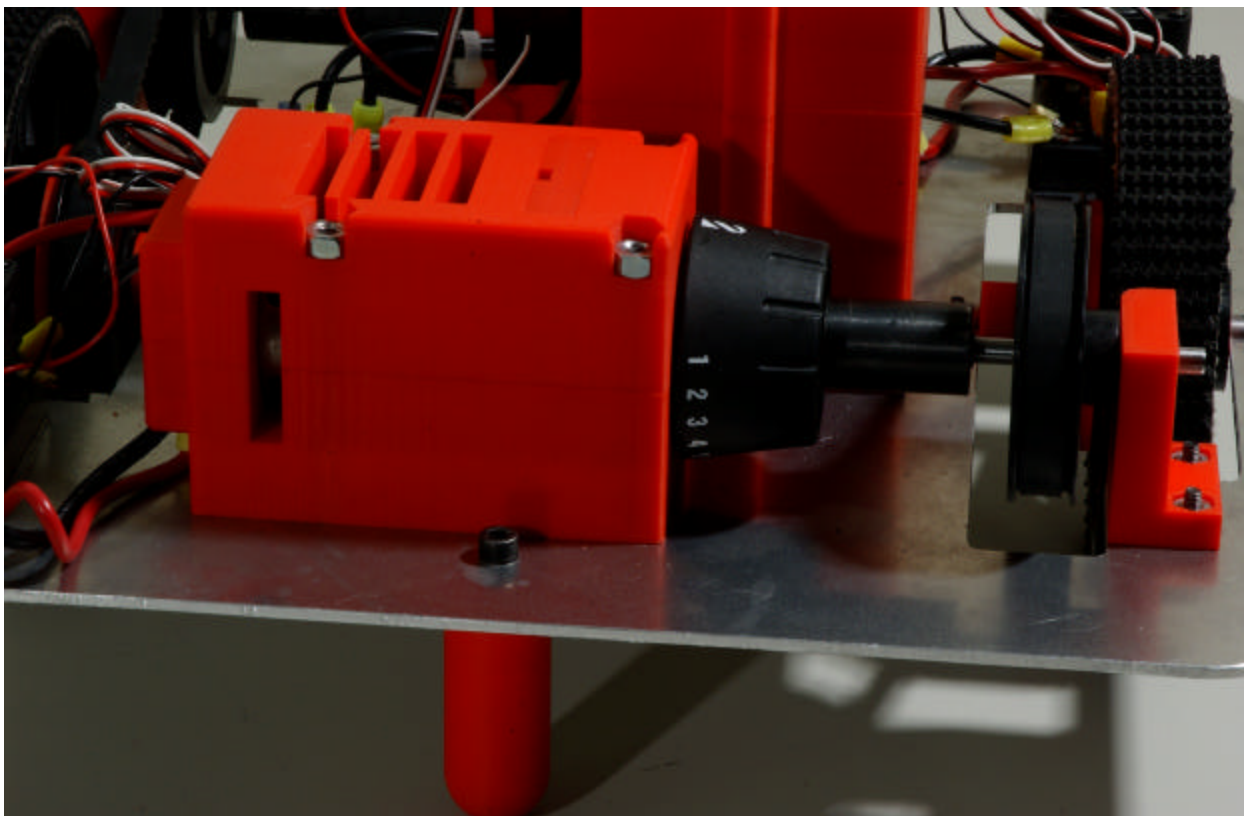


Figure 3